Social anxiety and attentional biases: A top-down contribution?

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Abstract

Selective attention toward threatening facial expressions has been found to precipitate and maintain symptoms of social anxiety. However, the automaticity of this bias is under debate. In the present study, we aimed to test whether top-down (controlled) engagement and disengagement of attention toward threatening faces is associated with social anxiety. This was examined by testing the impact of a secondary working memory (WM) load on attentional biases. In a variation of the dot-probe task, participants' attention was initially cued to the left or right of fixation before an upright face paired with an inverted face was presented (displaying a disgust or neutral expression), and participants responded to a subsequently presented probe. The task was performed under no-load, low-load (one-digit memory task), and high-load (six-digit memory task) conditions. Social anxiety was not found to be associated with delayed disengagement from threat. However, surprisingly, high social anxiety was associated with an engagement bias *away from* threat, whereas low social anxiety was associated with a bias *toward* threat. These results were unaffected by the WM load manipulation. This indicates that engagement with threatening facial expressions has minimal contributions from top-down mechanisms, since it is likely that orienting to facial expressions occurs relatively automatically.

Keywords: selective attention, spatial attention, working memory load, social anxiety, dot-probe.

Social anxiety and attentional biases: A top-down contribution?

When interacting with our environment, we are bombarded with visual information, only a small amount of which can be consciously processed due to our limited perceptual resources (Desimone & Duncan, 1995; Kastner & Pinsk, 2004). Selective attention is, therefore, used to filter information so that the visual system can preferentially attend to important and relevant aspects of the visual environment. Consequently, selective attention is integral in shaping our perception of the world around us. One factor that exerts a powerful influence over selective attention is an individual's level of anxiety. For example, although healthy individuals may show a small bias for preferentially processing threatening stimuli (e.g., feared objects such as snakes) over neutral stimuli, this bias is heightened for individuals with anxiety. Indeed, this threat bias is viewed as a core cognitive component of anxiety and central to many contemporary conceptualisations of clinical anxiety disorders and their treatments (Cisler & Koster, 2010). For example, some longitudinal studies suggest that threat biases in childhood predict the development of anxiety disorders later in life (Shechner et al., 2012). Furthermore, threat biases are involved in the maintenance of anxiety, since attentional training to reduce threat biases also reduces anxiety (for a review, see Bar-Haim, 2010).

Given the sensitivity *of socially anxious* individuals to negative social evaluation, threatening facial expressions hold special clinical significance for this population (Rapee & Heimberg, 1997). According to Rapee and Heimberg's cognitive model, individuals with social anxiety are hypervigilant to monitoring their external environment for signs of negative evaluation from others. For example, when giving a speech, a socially anxious individual will be more likely to scan their audience for facial signs of criticism or disapproval (e.g., frowning), which then increases their level of anxiety. This model is supported by research findings that socially anxious individuals show biased attention toward photos depicting angry, hostile, and disgust expressions compared with neutral facial expressions (Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2004).

In the present study, we aimed to test whether these threat biases are driven by bottom-up or top-down attention. *Top-down* attention refers to the voluntary allocation of attention toward particular objects, features, or spatial locations based on one's current goals. For example, when looking for a friend in a crowd, knowing that the friend is wearing a red scarf allows one to selectively attend to red objects. By contrast, *bottom-up* attention is an involuntary, rapid, and inflexible process that selects visual information based on the salience of the stimulus features. For example, while searching for a red object, an individual's attention may be captured by a flashing billboard even though the person had no intention to attend to that stimulus.

Traditionally, threat biases have been conceptualised as bottom-up. In line with this notion, evolutionary models posit that being able to respond to threat through bottom-up processing is adaptive (Kenrick, Neuberg, Griskevicius, Becker, & Schaller, 2010; Lang, Bradley, & Cuthbert, 1997; LeDoux, 1996; LoBue, Rakison, & DeLoache, 2010; Mogg & Bradley, 1998; Ohman, 2007). That is, being able to detect a threatening stimulus in the environment has evolved in the human species to facilitate survival (e.g., a fight or flight response to a predator) and is part of an automatic vigilance mechanism (Pratto & John, 1991). In support of this argument, research has shown that humans can engage early and rapid detection of low-level perceptual features associated with threatening images (LoBue, 2014; LoBue & DeLoache, 2011; LoBue & Larson, 2010). For example, using a visual search task, LoBue (2014) observed a bias toward curvilinear shapes (representative of snakes) compared with rectangular shapes. In addition, this bias to curvilinear shapes increases after watching a fearful film clip (LoBue, 2014), indicating that anxiety increases the detection of threat-relevant, low-level perceptual features. Similarly, biases for angry face features, such as the downward “V” shape of the eyebrows, have been found in both child and adult populations, which these authors argue indicates an evolved attentional bias for threatening stimuli (LoBue & Larson, 2010).

However, in opposition to this argument, research has found that threat detection does not always occur automatically. Visual search requires participants to detect an object or feature as rapidly as possible amongst distractor objects in a visual array. Using this task, past research has found that socially anxious individuals detect angry faces among neutral distractors more rapidly than happy faces among neutral distractors (Gilboa-Schechtman, Foa, & Amir, 1999). However, search times have been found to increase with added distractors (Eastwood, Smilek, & Merikle, 2001; Ohman, Lundqvist, & Esteves, 2001). Since automaticity in visual search has traditionally been conceptualised as being invariant to the number of distractors in the display (Treisman & Gelade, 1980), this suggests that the processing of threatening faces is not purely bottom-up as it requires attentional resources (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Vuilleumier & Righart, 2011).

The involvement of attentional resources in this process of orienting toward threat can be assessed with the use of working memory (WM) load. Previous research has found that tasks with high WM loads result in greater interference effects from visual distractors compared with low WM load tasks (de Fockert, Rees, Frith, & Lavie, 2001). Thus, voluntary, top-down selective attention can be impaired by WM load. By contrast, bottom-up attention is unaffected by WM load (e.g., Jonides, 1981). In the present study, therefore, we imposed a WM load to selectively impair the top-down attentional system without impacting bottom-up mechanisms.

Researchers employing WM load tasks have found some evidence that attentional biases can be overcome under high WM load (Pessoa et al., 2002; Van Dillen & Koole, 2009). For instance, Van Dillen and Koole employed an interference paradigm, in which participants viewed faces of varying expressions and were asked to indicate the gender of the faces. This study found that, as compared with happy faces, angry faces resulted in slower gender naming, but only under low-load. These researchers propose that, under high-load, negative stimuli do not capture attention because WM is fully engaged by the task. Only under low-load, when there are spare attentional resources, can negative stimuli are prioritised. However, this body of research has looked at interference effects from threatening stimuli that are presented individually at an attended location, rather than the capture of attention to the spatial location of a stimulus that is in competition with other stimuli elsewhere in the scene. Spatial attentional capture is particularly important to understanding threat biases for socially anxious individuals as they may cause individuals, when giving a speech for example, to attend to threatening faces in a top-down fashion, thus increasing their anxiety.

Recently, Judah, Grant, Lechner, and Mills (2013) assessed the top-down nature of the threat bias with socially anxious individuals by presenting participants with images of happy, disgust, and neutral facial expressions in a dot-probe task under three conditions: no, low, and high WM load. In the modified dot-probe task, two faces (e.g., one neutral and one negative) are presented on the computer screen, one to the left and one to the right of fixation. A probe (e.g., a letter) is then presented in the locus of one of the faces and participants are asked to respond to its identity. Faster reaction times (RTs) to respond to a probe appearing in the locus of a negative facial expression compared to a probe in the locus of a neutral facial expression indicates that participants' attention was captured by the negative face. This is known as a threat bias.

Judah et al. (2013) used a long presentation time for the faces (1000ms), which they claimed measured later attentional mechanisms of disengagement and avoidance. These researchers found that socially anxious individuals displayed avoidance of disgust expressions under no WM load but had difficulty disengaging attention under high WM load. However, one issue with this study, and that of the dot-probe design more generally, is that engagement and disengagement biases are conflated. Therefore, a threat bias can arise either due to enhanced engagement with that face or delayed disengagement from it. Although Judah et al. (2013) claimed that disengagement biases can be assessed using a long presentation time, this assumes that all participants initially shift their attention equally toward the threatening stimulus. If, however, individuals with higher levels of socially anxiety more readily engage with the threatening face, any attempt to measure the disengagement bias is conflated with engagement effects. Due to this issue, it cannot be determined whether the finding that social anxiety is linked to a threat bias is due to enhanced engagement or delayed disengagement effects.

Grafton and MacLeod (2014) and Rudaizky, Basanovic, and MacLeod (2014) have developed an elegant method for differentiating engagement biases from disengagement biases using a variation of the dot-probe task. In this design, on each trial participants viewed a target image (a threatening or neutral scene) paired with a non-representational image (abstract art) and participants’ shifts of attention toward and away from the location of the target image was measured. Specifically, these researchers presented an initial cue (a small red line oriented horizontally or vertically) before the presentation of the faces. This cue was presented either on the left or right side of the screen and, therefore, secured participants’ attention in the same location or opposite location to the target image. A disengagement trial was defined as a trial in which the target image was presented in the same location as the preceding cue, as participants were required to disengage their attention from the target to respond to a subsequent probe in the distal location. An engagement trial, by contrast, was defined as a trial in which the target was presented in the opposite location to the preceding cue, as these trials measured whether participants shifted their attention toward the target. After the cue and faces were presented, a probe (similar in appearance to the cue) was presented in the locus of one of the faces and participants were asked to indicate whether the probe was the same or a different orientation to the cue. On 50% of trials, the probe appeared in the distal location to the target face and on 50% of trials, it appeared in the proximal location. Therefore, for engagement trials, faster RTs in the proximal probe position compared with the distal position, indicated that participants shifted their attention toward the target face. Importantly, these distal-proximal probe difference scores were compared between trials in which the target image was negative compared with when it was neutral, to measure if greater engagement toward threat occurred for anxious participants. Similarly, difference scores were used to measure the disengagement bias to test whether participants had greater difficulty shifting away from the target image and responding to the distally presented probe, compared with the proximal probe, when a negative target image was used compared with a neutral target image. Both Grafton and MacLeod (2014) and Rudaizky et al. (2014) found that high trait anxious participants, compared with low trait anxious participants, have engagement biases and delayed disengagement biases for threat.

Although it was published after data collection for the present study was complete, a recent study employed a similar design to measure engagement and disengagement biases for participants with low and high social anxiety (Grafton & MacLeod, 2016). On each trial, negative and neutral faces were paired together and these researchers found that participants with high social anxiety had a greater engagement bias toward negative facial expressions compared with participants with low social anxiety. Social anxiety was not found to be associated with difficulties disengaging from threat. These data indicate the importance, therefore, of differentiating these biases from one another. The present study will extend on Grafton and MacLeod’s research by testing whether these biases are driven by top-down or bottom-up attentional orienting (Corbetta & Shulman, 2002; Posner, 1980). Specifically, the present study includes an additional WM load task to test if attentional biases are affected by high WM load, which would indicate that they are driven by top-down attention.

Present Experiment

In the present study, we sought to investigate the contribution of top-down attention in the selective processing of threatening visual information for individuals with high social anxiety. This was tested using a variation of the dot-probe task (Grafton & MacLeod, 2014; Rudaizky et al., 2014), in which participants were presented with neutral and disgust facial expressions and their engagement with and ability to disengage from these faces were measured. The dot-probe task provides an opportunity to measure spatial attention, which is of particular clinical relevance to social anxiety and also allows for the separate analysis of engagement and disengagement biases. Engagement and disengagement biases were compared under three conditions: no WM load, low WM load, and high WM load. WM load was used to deplete top-down attentional resources. Under no and low WM load, it was expected that higher social anxiety would be associated with an engagement bias toward the disgust faces. If the engagement bias is driven by bottom-up attention, this bias would be unaffected by the load manipulation. However, if the engagement bias is driven by top-down attention, this bias would be attenuated under high WM load. Regarding disengagement effects, recent research has found that social anxiety is not associated with delayed disengagement from threat (Grafton & MacLeod, 2016). However, trait anxiety, which shares many similar features with social anxiety, has been found to be associated with delayed disengagement from threat (Grafton & MacLeod, 2014; Rudaizky et al., 2014). With this study, therefore, we aimed to elucidate whether social anxiety is associated with delayed disengagement from threat and, if it is, whether it is affected by WM load.

Method

Participants and Design

One hundred participants (53 female) were recruited from the Australian National University via online advertisement and the university electronic sign-up system and these participants completed the experiment in exchange for course credit or $30 payment. Participants all reported to have normal or corrected vision, their ages ranged from 17 to 36 years (*M*=22.43, *SD*=3.62) and 91 of them were right-handed. Participants' social anxiety scores, as measured by the Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1989) ranged from 3 to 64 (*M*=26.18, *SD*=12.94). These scores are somewhat higher than would be expected based on the normative data of Heimberg, Mueller, Holt, Hope, and Liebowitz (1992), who found a mean of 19.9 on the SIAS in a community sample. Heimberg et al. (1992) defined the clinical cut-off for social phobia as equal to or greater than 34 on the SIAS, which reflected one SD above the mean score of the community sample.

Participants' depression scores on the depression component of the Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995) ranged from 0 to 39 (*M*=5.69, *SD*=5.79) and, as measured with the State-Trait Anxiety Scale (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), state anxiety ranged from 20 to 62 (*M*=33.7, *SD*=9.21) and trait anxiety ranged from 24 to 72 (*M*=42.55, *SD*=9.06). All participants provided written informed consent prior to participation and provided demographic information. Table 1 presents demographic and self-report scores for participants with low and high social anxiety, as calculated using a median split.

Table 1
Demographic and self-report scores for low and high social anxiety groups

	Participants *(Female)*	**Age** *M(SD)*	**SIAS** *M(SD)*	**DASS-D** *M(SD)*	**STAI-S** *M(SD)*	**STAI-T** *M(SD)*
Low social anxiety	50 (26)	22.26 (3.39)	15.72 (5.65)	3.66 (3.86)	30.10 (7.00)	36.54 (7.47)
High social anxiety	50 (27)	22.40 (3.66)	36.64 (9.10)	7.72 (6.67)	37.30 (9.79)	46.56 (8.79)

Images

Images of faces was taken from the FACES database (Ebner, Riediger, & Lindenberger, 2010), consisting of the neutral and disgust expressions from Set A of the young age range (ages 19-31). Since research has found a same-age facial recognition bias (Rhodes & Anastasi, 2012), the young age range faces were included in this study to match the average age of participants. On each trial the two faces presented were taken from the same face model so that they were matched for facial properties, and one image was presented upright and one image was inverted. Each image subtended 6.81 x 8.52° of visual angle.

Experimental Task

Participants completed the demographic questions, the SIAS, STAI, and depression items from the DASS, and then participated in the computer task. This experiment was conducted in a dimly lit room. Stimuli were presented on a cathode-ray tube (CRT) gamma-corrected monitor running at a 75Hz refresh rate. Viewing distance was set with a chinrest at 44cm. Stimuli were programed in Matlab using the Psychophysics Toolbox (Brainard, 1997) and the background was set to black.

The computer task consisted of three blocks of trials (no-load, low-load, and high-load) counterbalanced across participants. Each block consisted of 224 trials and so each participant completed a total of 672 trials. Before each block, participants completed five practice trials with corrective feedback.

In the low- and high-load conditions, a number was presented centrally on the screen at the beginning and end of each trial (see Figure 1). A single-digit number was used in the low-load condition and a six-digit number was used in the high-load condition. The digits in these numbers could range between 1 and 9 and were generated using a random number generator. On approximately half the trials the number presented at the end of the trial matched the one presented at the beginning and on approximately half of the trials it changed. In the high-load condition, the number could only change by one of the digits so the participant was required to remember all six digits to determine if it was the same or different. For the low-load task, the single-digit number was presented for 1000ms, whereas in the high-load task, the six-digit number was presented for 3000ms, which provided sufficient time to read the number strings. Participants were then asked to make a same/different keyboard press to indicate whether it matched the number presented at the beginning of the trial.

Regarding the main probe task, initially a blank screen was presented for 1000ms. On each trial two white rectangular outlines were initially presented, one to the left and one to the right of fixation for 1000ms. These rectangular outlines subtended 6.81 x 8.52° of visual angle and the width of the lines subtended 0.089°. A smaller red rectangle, subtending 1.70 x 2.13°, was also presented inside one of the white rectangles to indicate the location of the to-be-presented cue. The cue (a small red line) was then presented within the box for 200ms. This cue could be oriented horizontally or vertically and subtended a visual angle of 0.48° and had a width of 0.089°.

After these stimuli disappeared, two images of faces were presented for 500ms, one to the left and one to the right of fixation, such that they occupied the locations that the white rectangles previously occupied. After these faces offset, a probe (a small red line) oriented horizontally or vertically, which was identical in appearance to the cue, was then presented in the locus of one of the faces and was oriented horizontally or vertically. Participants made a keyboard press to report whether the orientation of the probe matched the orientation of the cue as quickly and accurately as possible. The variables (location, orientation, and image type) were randomised, with the restriction that an equal number of trials consisted of disengagement or engagement trials, negative or neutral upright photos, and that the probe was distal or proximal to the upright image

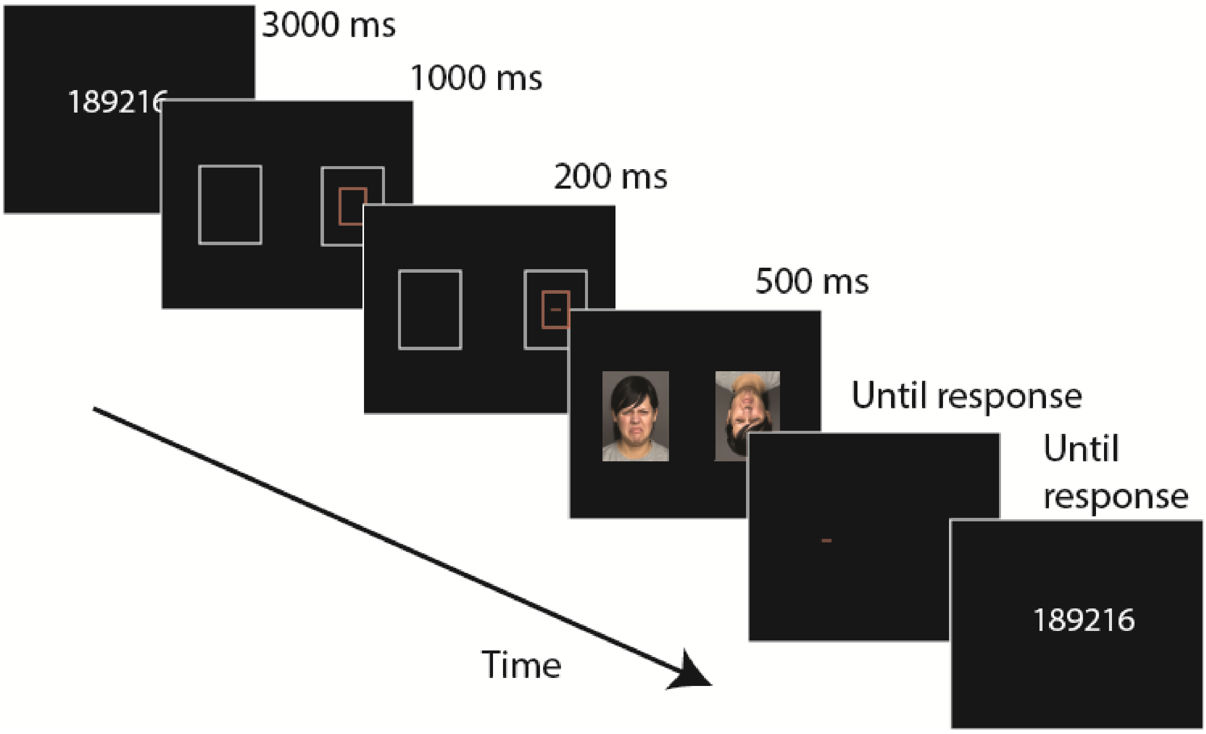


Figure 1. A schematic of an engagement trial under high-load.

An engagement trial was defined as a trial in which the upright face was presented in the opposite location of the preceding cue (for a discussion, see Rudaizky et al., 2014). This is because these trials measure the likelihood that participants will shift their attention toward the upright face. By contrast, for disengagement trials, the upright face was presented in the same location as the preceding cue. Therefore, participants were required to disengage their attention from the upright face to respond to a subsequent probe in the distal location.

Calculation of bias indices. In accordance with the method developed by Grafton and MacLeod (2014) and Rudaizky et al. (2014), engagement bias and disengagement bias indices were calculated. Higher scores for the attentional engagement bias index reflects facilitated attentional orienting toward the disgust expression compared with the neutral expression. The equation is as follows:

> Engagement bias index = (Cue probe distal to upright negative image in upright negative/inverted image pair: RT for target probes distal to upright negative image minus RT for target probes proximal to upright negative image) minus (Cue probe distal to neutral upright image in neutral upright/inverted image pair: RT for target probes distal to upright neutral image minus RT for target probes proximal to upright neutral image).

Similarly, higher scores for the attentional disengagement bias index reflects greater difficulty disengaging from the disgust expression compared with the neutral expression. The equation is as follows:

> Disengagement bias index = (Cue probe proximal to upright negative image in upright negative/inverted image pair: RT for target probe distal to upright negative image minus RT for target probe proximal to upright negative image) minus (Cue probe proximal to upright neutral image in upright neutral/inverted image pair: RT for target probe distal to upright neutral image minus RT for target probe proximal to upright neutral image).

Results

The data from two participants were excluded due to technical failure. A further participants' data were excluded due to responding quicker than 100ms throughout the experiment, indicating random responding. Finally, three participants' data were excluded as their overall RTs were slower than 3.29 SDs from average. Therefore, 94 participants' data were included in further statistical analyses.

The mean accuracies on the probe task was 94.96% (*SD*=3.47) in the no-load condition, 96.89% (*SD*=2.72) in the low-load condition, and 96.08% (*SD*=2.83) in the high-load condition. The mean accuracy on the digit-span task was significantly ($t(93)=7.10$, $p<.001$) higher in the low-load condition (*M*=94.56%, *SD*=4.17) compared with the high-load condition (*M*=89.94%, *SD*=7.79) indicating that, as expected, the six-digit task was more difficult than the one-digit task.

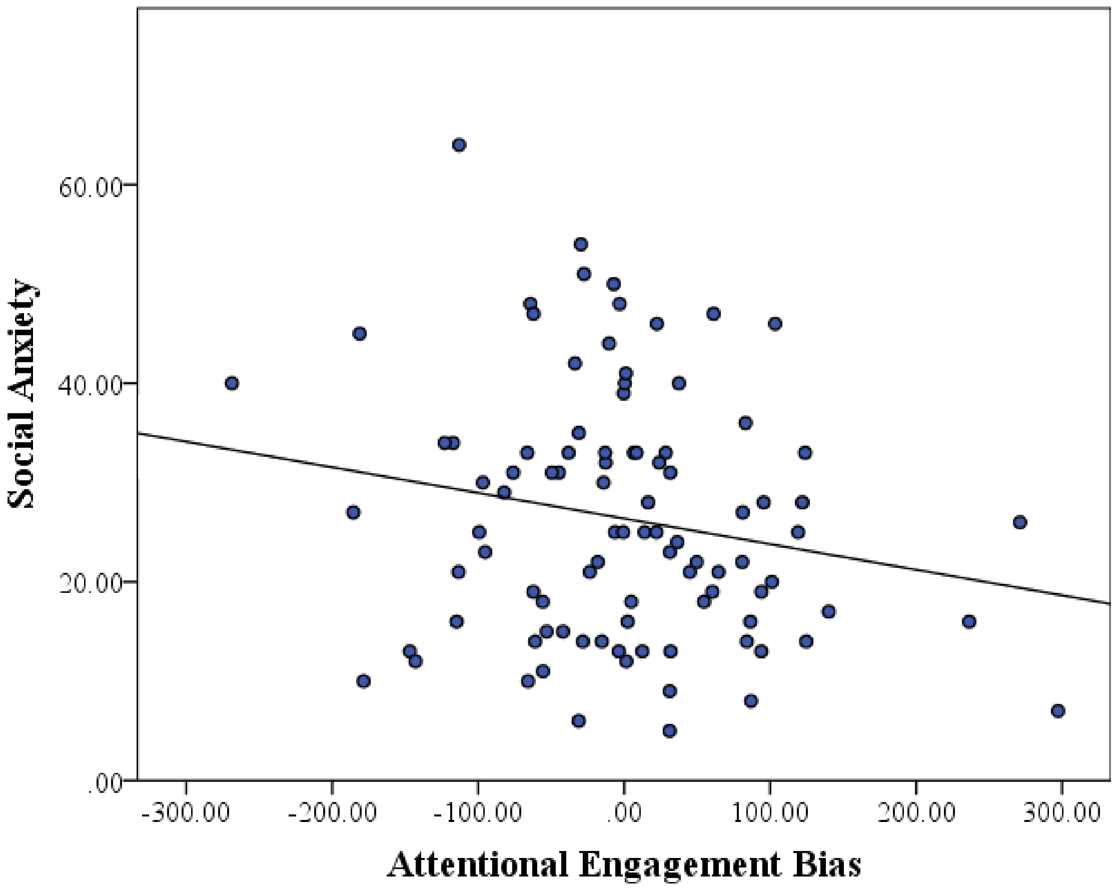
Data from trials in which participants performed incorrectly on the probe task were excluded from analyses because this indicates that participants were not attending in the correct location at the beginning of the trial. In addition, in the low- and high-load conditions, trials in which participants responded incorrectly on the digit task were excluded as the load manipulation may not have been successful on these trials. Further exclusions were made for trials in which RTs were less than 100ms or greater than 2.5 standard deviations above the individual participant's mean RT. Each participants' mean performance was then calculated for each condition. The average percentage of excluded trials was 7.60% for the no-load condition, 13.26% for the low-load condition, and 18.20% for the high-load condition.

Engagement Bias

Since the construct of social fear is a continuous variable in the population (McNeil, 2010), social anxiety was analysed as continuous in this study. Furthermore, since engagement and disengagement biases are separate attentional processes (Grafton & MacLeod, 2014), they were analysed separately. Using the engagement bias index equation, each participant's engagement bias was calculated. To analyse the engagement bias, a repeated-measures ANCOVA was performed with the within-subject factor of load (no, low, and high) and the continuous variable of social anxiety. Mauchley's test indicated that the assumption of sphericity had been violated for load ($\chi^2(2)=15.53$, $p<.001$) and, therefore, degrees of freedom were corrected using the Greenhouse-Geisser estimate of sphericity ($\varepsilon = .86$).

Load was not found to be significant ($F(1.73, 91)=.85$, $p=.416$, $\eta_p^2=.009$), which indicates that the engagement bias index did not alter across the no-load, low-load, and high-load conditions. In addition, the interaction between load and social anxiety was not significant ($F(1.73, 91)=.64$, $p=.507$, $\eta_p^2=.007$). However, a significant *trend effect* was found for the relationship between social anxiety level and the engagement bias index ($F(1, 92)=3.12$, $p=.081$, $\eta_p^2=.033$). Scatterplots revealed that, surprisingly, the engagement bias index *decreased* with increasing levels of social anxiety. To quantify the effect, a median split was conducted to compare participants with low versus high social anxiety. Participants with low social anxiety had a mean engagement bias index of 4.97ms and participants with high social anxiety had a mean engagement bias index of -6.61ms. This indicates that low social anxiety was associated with a slight bias *toward* disgust expressions and high social anxiety was associated with a slight bias *away* from disgust expressions. Raw data are presented in Appendix A.

Post-hoc exploratory analyses. Due to past research indicating that people rapidly habituate to threatening images (Breiter et al., 1996; Staugaard, 2009), it was hypothesised that the threat bias may have diminished over the course of the experiment. To further elucidate the trend engagement effect found in the previous analysis, the data from participants' first block (224 trials) of data were analysed. An ANCOVA was performed with the between-subjects factor of load (no, low, and high) and the continuous predictor variable of social anxiety. The main effect of load was not significant ($F(2, 90)=1.51$, $p=.227$, $\eta_p^2=.032$), confirming that load did not impact engagement toward disgust expressions. However the impact of social anxiety on the engagement bias index was significant ($F(1, 90)=4.66$, $p=.034$, $\eta_p^2=.049$). Similar to the overall analysis, observation of scatterplots (see Figure 2) indicated that the engagement bias index decreased with higher levels of social anxiety. In addition, a median split indicated that participants with low social anxiety had an engagement bias index of 10.26ms, which suggests that they had a bias toward threat, and



participants with high social anxiety had an engagement bias index of -10.50ms, indicating a bias away from threat. Raw data are presented are Appendix B.

Figure 2. Relationship between social anxiety and attentional engagement toward threat.

Disengagement Bias

To analyse the disengagement bias index, a repeated-measures ANCOVA was performed with the within-subject factor of load (no, low, and high) and the continuous predictor variable of social anxiety. Load was not significant ($F(2, 91)=.03$, $p=.975$, $\eta_p^2 \leq .001$), which indicates that the disengagement bias index did not alter across the no-load, low-load, and high-load conditions. In addition, no significant effects were found for social anxiety level ($F(2, 91)=.283$, $p=.596$, $\eta_p^2=.003$) or the interaction between load and social anxiety ($F(2, 91)=.95$, $p=.387$, $\eta_p^2=.010$). This indicates that social anxiety was not associated with difficulty disengaging from disgust facial expressions.

A sidenote on these results was that, unexpectedly, participants were faster to respond to a probe presented in the distal location (M=698ms) compared with the proximal location (M=717ms) of the upright image ($F(1, 92)=6.06$, $p=.016$, $\eta_p^2=.062$). This suggests that participants had already disengaged from the upright image, both for neutral and disgust expressions, when the probe appeared. The implications of this are addressed in the discussion.

Discussion

Despite the proliferation of research exploring attentional biases, the differential roles of bottom-up and top-down attentional mechanisms remain unclear. Using a variation of the dot-probe task, the present project aimed to test whether engagement and disengagement biases toward negative facial expressions for individuals with higher levels of social anxiety are driven by top-down attention. Specifically, the present project employed a WM load task to manipulate the availability of top-down attentional resources to test if this impacted attentional biases toward threat.

Do Socially Anxious Individuals have an Engagement Bias toward Threat?

Surprisingly this study did *not* find any evidence that individuals with higher social anxiety have an engagement bias toward disgust expressions compared with neutral expressions. In fact, the study found the opposite effect. Although only significant at trend levels (p =.081), the present study found that increasing levels of social anxiety was associated with a decreased engagement bias. In fact, individuals with high social anxiety were faster to respond to probes following neutral expressions compared with the disgust expressions, indicating a bias *away* from threat.

We hypothesised that the effects may have become diluted over the course of the experiment due to habituation to threat. The present study included 224 trials per load condition, which totalled 672 trials per participant. Past research indicates that participants rapidly habituate to emotional faces in the dot-probe task (Staugaard, 2009), which may have accounted for the small effect that was found. To explore this possibility, each participants' first block of trials (totalling 224 trials) were analysed separately. The trend that was found in the previous analysis was now significant (p=.034), indicating that participants with lower levels of social anxiety had an engagement bias toward the disgust expressions and participants with high social anxiety had a bias away from the disgust expressions.

These results differ from Grafton and MacLeod's (2016) study, which found that socially anxious individuals had an engagement bias toward negative facial expressions. This is surprising as these two studies aimed to measure the same attentional processes. However, there are some differences in the experimental design, which may account for these opposing results. In Grafton and MacLeod's (2016) study, they paired negative and neutral faces together on each trial. By contrast, the present study was more similar to the design employed by Grafton and MacLeod (2014) and Rudaizky et al. (2014) who presented the neutral and negative images on separate trials. However, whereas Grafton and MacLeod (2014) and Rudaizky et al. (2014) paired the threat and neutral scenes with an abstract image on each trial, the present study paired negative and neutral faces with their inverted face counterpart to control for low level visual properties that may capture attention. Any of these methodological differences, either individually or in concert, may be the reason for the contrasting pattern of results.

The lack of threat engagement bias for high socially anxious individuals found in this study reflects the complex nature of attention. For instance, past research has found enhanced engagement toward threat, delayed disengagement from threat, avoidance of threat, or even no biases at all (see Cisler & Koster, 2010). Furthermore, research has recently emerged suggesting that anxiety is associated with high variability in attending to threat (Zvielli, Bernstein, & Koster, 2015). On a dot-probe task, Zvielli et al. (2015) calculated a trial-level bias score by subtracting temporally contiguous pairs of congruent trials (when the probe was presented in the locus of a threatening image) with incongruous trials (when the probe was presented in the locus of a neutral image). This study found that, compared to healthy controls, spider phobics had greater variability in attentional capture throughout the experiment, sometimes displaying biases toward spider-related material and sometimes displaying biases away from threat. An average bias score across an experiment does not reveal these temporal dynamics. The current bias away from threat could, therefore, reflect the fact that the socially anxious participants tended to avoid the threatening faces for longer (more trials) after initially engaging with the threatening face.

A second possibility is that individuals with high social anxiety were attracted to the threat value of the *inverted* face. Inverted faces were selected as the paired face to control for attentional capture due to low-level perceptual differences across the two presented images.

Furthermore, a large body of research indicates that emotion processing of faces is disrupted by inversion as the spatial-relations of the face are not properly processed (de Gelder, Teunisse, & Benson, 1997; Searcy & Bartlett, 1996). However, more recent research indicates that, although inverted faces are processed in a more piecemeal manner, rapid emotion detection can still occur (Arnold & Lipp, 2011). As described previously, the cognitive model of social anxiety posits that individuals with social anxiety are hypervigilant to monitoring their external environment for signs of negative evaluation from others (Rapee & Heimberg, 1997). In the presence of threat, it is possible that this hypervigiliance displayed by socially anxious individuals caused them to monitor the inverted face as well as the upright face. Further research is, therefore, needed to test whether the lack of engagement bias displayed by highly socially anxious individuals is driven by greater temporal variabiliy or due to the choice of inverted face as the paired image.

Do Socially Anxious Individuals have a Disengagement Bias toward Threat?

The present study found no evidence that socially anxious individuals have a disengagement bias toward disgust expressions. This is consistent with Grafton and MacLeod's (2016) conclusion that social anxiety is associated with unusual engagement toward threat but not difficulty disengaging from threat. However, one potential issue with this conclusion is that the present study found faster RTs in the distal probe position compared with the proximal probe position. This means that on average, when the probe appeared, participants had already disengaged their attention from the position of the target face. It is possible that a briefer presentation time for the faces is needed to capture a delayed disengagement effect as the present study employed a presentation time of 500ms.

A further reason to be hesitant to conclude that socially anxiety is not associated with delayed disengagement is that trait anxiety, which has similar theoretical underpinnings to social anxiety, is associated with delayed disengagement from threat (Grafton & MacLeod, 2014; Rudaizky et al., 2014). For instance, using 500ms and 1000ms presentation times, Rudaizky et al. (2014) paired visual scenes (threatening or neutral) with images of abstract art and found that participants with high trait anxiety had a delayed disengagement bias for threat compared with low trait anxious participants. It is possible that participants may take longer to process complex visual scenes than faces, therefore, taking longer to disengage attention from a visual scene compared with a face. Interestingly, Grafton and MacLeod (2014), who utilised a similar design to Rudaizky et al. (2014), found delayed disengagement from threat for high trait anxious participants at 100ms stimulus durations but not 500ms stimulus durations. Disengagement effects, therefore, may be more robust for short stimulus presentation times. This indicates that, before conclusions about social anxiety and disengagement effects can be made, it is essential for further research to test these effects at durations shorter than 500ms.

The Effect of WM Load on Engagement and Disengagement Biases

In addition to measuring engagement and disengagement threat biases associated with social anxiety, the present study aimed to test whether these were driven by top-down attention. This study found no effect of WM load for both the engagement and disengagement analyses. Unfortunately, since a social anxiety related disengagement bias toward threat was not found, the impact of WM load on such a bias cannot be determined. However, although the engagement effects were unexpected, an engagement bias toward threat was found for low socially anxious individuals and a bias away from threat was found for high socially anxious individuals. These results were unaffected by the load manipulation, indicating that they are bottom-up. This result is in accordance with the traditional view that anxiety is associated with an overactive bottom-up threat detection system (Mogg & Bradley, 1998; Ohman, 2007).

Conclusion and Implications

In sum, the present study indicated that social anxiety is associated with unusual engagement with negative facial expressions. Specifically, participants with high social anxiety had a slight bias away from threat and participants with low social anxiety had a bias toward threat. This was unaffected by WM load, which indicates that engagement with threat requires few attentional resources and is, therefore, largely driven by bottom-up attention. Social anxiety was not found to be associated with differences in disengagement from threat. Due to mixed findings in the literature, further research is now needed to clarify the conditions under which high social anxiety is associated with biases either *toward* or *away* from threat. In addition, as discussed previously, further research using shorter presentation times is needed before concluding that social anxiety is not associated with delayed disengagement from threat.

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Appendix A

Data Summary

Data for the no-load, low-load and high-load conditions are presented in Table A1, Table A2, and Table A3, respectively. In addition, attentional engagement bias index and disengagement bias index data are presented in Table A4. Low and high social anxiety groups were calculated using a median split.

Table A1
Mean response times (ms) obtained in the no-load condition for low and high social anxiety groups

Cue locus	**Image valence**	**Target probe locus**	**Low social anxiety *M (SD)***	**High social anxiety *M (SD)***
Distal	Negative	Distal	723.24 (140.27)	688.49 (151.48)
(*attentional engagement trials)*		Proximal	696.82 (140.87)	656.02 (155.37)
	Neutral	Distal	731.97 (147.31)	692.72 (157.55)
		Proximal	691.95 (159.26)	655.33 (173.96)
Proximal	Negative	Distal	711.45 (144.62)	684.94 (163.66)
(*attentional disengagement trials)*		Proximal	743.72 (151.00)	700.86 (174.18)
	Neutral	Distal	696.83 (139.50)	670.15 (160.89)
		Proximal	724.91 (159.45)	685.95 (151.10)

Table A2
Mean response times (ms) obtained in the low-load condition for low and high social anxiety groups

Cue locus	**Image valence**	**Target probe locus**	**Low social anxiety *M (SD)***	**High social anxiety *M (SD)***
Distal	Negative	Distal	780.42 (167.80)	721.12 (175.19)
(*attentional engagement trials)*		Proximal	760.50 (168.82)	712.69 (207.34)
	Neutral	Distal	786.83 (179.25)	755.62 (216.03)
		Proximal	776.43 (193.29)	724.63 (183.32)
Proximal	Negative	Distal	773.63 (181.00)	724.86 (191.63)
(*attentional disengagement trials)*		Proximal	792.65 (195.46)	725.72 (169.50)
	Neutral	Distal	756.25 (165.45)	720.51 (186.21)
		Proximal	785.41 (170.95)	744.75 (184.28)

Table A3

Mean response times (ms) obtained in the high-load condition for low and high social anxiety groups

Cue locus	**Image valence**	**Target probe locus**	**Low social anxiety *M (SD)***	**High social anxiety *M (SD)***
Distal (*attentional engagement trials)*	Negative	Distal	712.25 (148.15)	649.01 (108.89)
		Proximal	671.27 (144.95)	624.89 (112.56)
	Neutral	Distal	697.32 (150.32)	645.99 (108.80)
		Proximal	675.31 (143.51)	629.50 (103.89)
Proximal (*attentional disengagement trials)*	Negative	Distal	680.27 (157.41)	634.69 (119.23)
		Proximal	708.97 (151.39)	655.56 (118.55)
	Neutral	Distal	674.31 (134.42)	648.35 (130.86)
		Proximal	698.97 (153.45)	642.09 (126.56)

Table A4

Means and standard deviations of attentional bias index scores for the three load conditions

	Load condition	**Engagement bias**	**Disengagement bias**
Low social anxiety *M (SD)*	No load	-13.60 (94.07)	-4.19 (93.60)
	Low load	9.52 (112.44)	10.15 (80.05)
	High load	18.98 (100.65)	-4.05 (124.66)
High social anxiety *M (SD)*	No load	-4.91 (76.92)	-0.12 (75.77)
	Low load	-22.56 (115.26)	23.38 (90.77)
	High load	7.63 (73.38)	-27.12 (93.21)

Appendix B

Data Summary: First Block of Trials

Data for the no-load, low-load and high-load conditions for participants' *first block* of trials (224 trials) are presented in Table B1, Table B2, and Table B3, respectively. In addition, attentional engagement bias index and disengagement bias index data are presented in Table A4. Low and high social anxiety groups were calculated using a median split.

Table B1
Mean response times (ms) obtained in the no-load condition for low and high social anxiety groups for block one of trials

Cue locus	Image valence	Target probe locus	Low social anxiety *M (SD)*	High social anxiety *M (SD)*
Distal	Negative	Distal	710.058(134.71)	799.34 (151.82)
(*attentional engagement trials)*		Proximal	702.54 (163.45)	752.71 (149.92)
	Neutral	Distal	722.72 (148.28)	809.19 (162.17)
		Proximal	683.19 (156.20)	778.05 (187.63)
Proximal	Negative	Distal	722.66 (168.05)	799.73 (152.24)
(*attentional disengagement trials)*		Proximal	729.73 (140.94)	822.73 (203.16)
	Neutral	Distal	707.75 (162.00)	780.81 (150.22)
		Proximal	694.61 (118.85)	785.94 (158.89)

Table B2
Mean response times (ms) obtained in the low-load condition for low and high social anxiety groups for block one of trials

Cue locus	Image valence	Target probe locus	Low social anxiety *M (SD)*	High social anxiety *M (SD)*
Distal	Negative	Distal	854.28 (162.58)	725.13 (140.48)
(*attentional engagement trials)*		Proximal	824.28 (172.89)	740.04 (175.22)
	Neutral	Distal	839.20 (172.10)	753.05 (174.54)
		Proximal	834.99 (197.25)	726.63 (151.73)
Proximal	Negative	Distal	857.06 (179.15)	733.91 (151.94)
(*attentional disengagement trials)*		Proximal	861.56 (156.94)	741.99 (158.85)
	Neutral	Distal	831.80 (179.33)	727.39(136.719)
		Proximal	852.97 (167.62)	736.03 (163.06)

Table A3

Mean response times (ms) obtained in the high-load condition for low and high social anxiety groups for block one of trials

Cue locus	**Image valence**	**Target probe locus**	**Low social anxiety *M (SD)***	**High social anxiety *M (SD)***
Distal (*attentional engagement trials)*	Negative	Distal	795.51 (94.36)	654.04 (83.84)
		Proximal	729.99 (106.39)	645.42 (108.40)
	Neutral	Distal	783.62 (112.04)	658.37 (86.81)
		Proximal	767.76 (95.05)	643.53 (104.24)
Proximal (*attentional disengagement trials)*	Negative	Distal	756.83 (124.60)	652.17 (108.39)
		Proximal	784.69 (108.30)	678.97 (91.45)
	Neutral	Distal	717.69 (89.50)	674.93 (115.75)
		Proximal	785.98 (145.19)	660.09 (98.46)

Table B4

Means and standard deviations of attentional bias index scores for the three load conditions for block one of trials

	Load condition	**Engagement bias**	**Disengagement bias**
Low social anxiety *M (SD)*	No load	-32.01 (60.84)	-20.21 (66.91)
	Low load	25.80 (107.87)	16.68 (87.76)
	High load	49.66 (92.51)	40.44 (160.04)
High social anxiety *M (SD)*	No load	-15.49 (100.77)	-17.88 (81.02)
	Low load	-41.34 (99.16)	0.56 (105.43)
	High load	-6.22 (69.05)	-41.65 (69.21)